

COMPENSATION CONSENSUS

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What is Compensation?

*“It is claimed that smokers “compensate” for the reduced tar and nicotine yields of some brands by smoking them differently than smokers of higher yield brands. **Generally, the more intensely a smoker smokes a cigarette, the more tar and nicotine he or she will inhale from that cigarette.**”*

<http://www.philipmorrisusa.com> 8-Nov-00

Philip Morris U.S.A. -- Company & Products -- Tar & Nicotine Numbers

What is Compensation?

“...[s]mokers may increase the number of cigarettes they smoke and inhale more deeply when they switch to lower yield cigarettes. Compensatory behavior may negate any advantage of the lower yield product or even increase the health risk.”

U.S. Surgeon General's Report, 1981, p. vi

What is Compensation?

“The overall evidence suggests that many smokers compensate when smoking low-delivery cigarettes by inhaling more tar and nicotine than are measured by smoking machines under standard conditions. Any potential health benefit implied by machine measurements of lower tar and nicotine yields may thus be mitigated by such compensatory smoking.”

U. S. Surgeon General's Report, 2000, p. 184

What is Compensation?

“This combination provides a standard, uniform analytical procedure which will give reproducible results within and between laboratories. . . .”

Pillsbury, Bright, O'Connor, and Irish, JAOAC, **52**(3), 1969, pp. 458 - 462

What is Compensation?

“Compensation or compensatory smoking, accurately defined, deals with the question of whether switching to cigarette brands with different smoke yields is associated with a change in smoke uptake proportional to the change in machine-derived yields.”

Scherer, *Psychopharmacology*, 145:1-20, 1999

Literature Review

- >150 research reports identified
 - Smoking behavior in relation to cigarette yields
 - Compensation for nicotine
 - Compensation for other factors
- Studies of conventional cigarette products

Smoking Behavior Relative to Cigarette Yield

Ten cross-sectional studies reported no association between yield and cigarette consumption.

The Compensation Index

- Concept articulated by several authors
- Compensation Index CI =

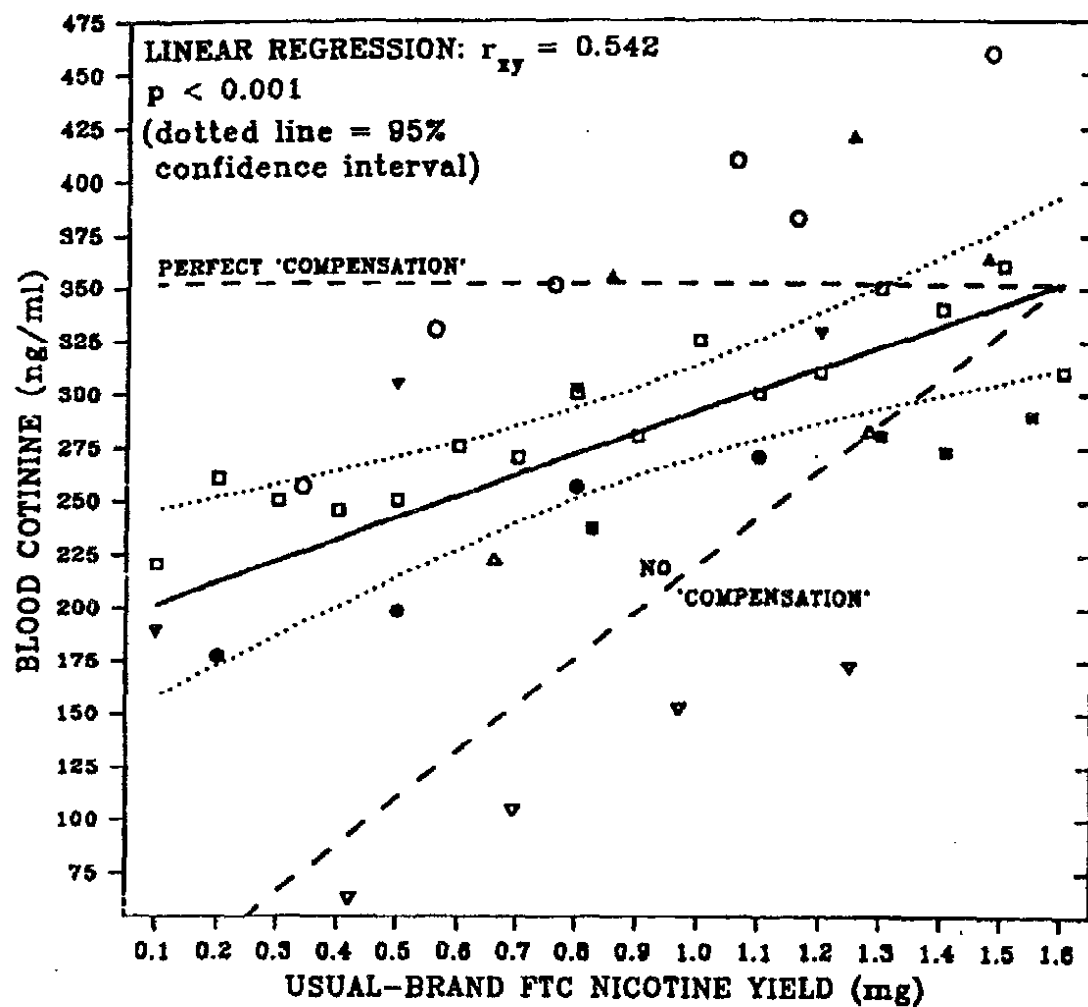
$$1 - \frac{\% \text{ change in uptake}}{\% \text{ change in yield}}$$

Relationship of Biomarkers to Smoke Yields

From a meta analysis of eight studies of ~5000 smokers, the correlation between blood cotinine concentrations and machine-derived nicotine levels suggests “incomplete compensation”

Pritchard and Robinson, *Psychopharmacology*, 124: 282-284, 1996

Pritchard and Robinson Meta-Analysis



Psychopharmacology, 124: 282-284, 1996

Experimental Brand-switching Studies

- Extensive literature on brand-switching
- Longitudinal rather than cross-sectional

Results of Experimental Brand-switching Studies

- Number of cigarettes smoked per unit time after switching unchanged in the majority of studies
- Smoking to a different butt length does not appear to be an important parameter in compensation

Results of Experimental Brand-switching Studies

- Puff volume increases as yield is decreased
- Puffing pattern changes with switching to lower or higher yield cigarette
- Inhalation pattern only rarely investigated, and typically no change was observed after switching

Results of Experimental Brand-switching Studies

- Switching to higher nicotine yield cigarette increased nicotine uptake
- Switching to lower nicotine yield cigarette decreased nicotine uptake

Results of Experimental Brand-switching Studies

*“However, in most of the investigations, it was found that the change in [nicotine] uptake was less than predicted from the change in cigarette yields, suggesting **partial** compensation.” (emphasis added)*

Scherer, *Psychopharmacology*, 145:1-20, 1999

Why vs. How

- Motivation: **Why** a smoker exhibits compensatory behavior (i.e., taste, specific smoke constituent)
- Mechanism: **How** a smoker alters his smoking behaviors to compensate (i.e., changes in puff volume, changes in puff frequency)

The Consensus

- Changing the cigarette yield can result in **partial compensation** by some smokers
- Smoke constituent[s] which **motivate** changes in smoking behaviors have been assumed *a priori* to be nicotine
- The **degree** and **duration** of partial compensation is unknown
- The impact of **intra- and inter-individual differences** is not well understood

Partial Compensation

- Supported by the scientific literature
- Impact of measurement of behavior on that behavior not known
- Apparently results from change in puff volume rather than from changing the number of cigarettes or vent blocking

Motivation to Compensate

- Compensatory behaviors monitored most often by measures of nicotine and cotinine
- Role of tar and other smoke constituents, sensory effects, cigarette pressure drop, functional autonomy, and personality type unknown

Degree and Duration of Effect

- Observation in reported studies (days to weeks) too short to assess behavioral adaptations
- These quantitative aspects expected to be ranges rather than point estimates
- For how long and to what degree smokers exhibit compensatory behaviors is not known

Intra- and Inter-individual Effects

“Human smoking behavior is highly variable” is the first observation related by Scherer (1999 review)

Implications for Future Research

It is unlikely that further research would change the consensus opinion that some smokers partially compensate. However, there are gaps in our understanding of partial compensation in terms of quantification of the effect, motivations, temporality, and mechanisms.

Assessment of Future Compensation Studies

- Statistical power (e.g., number of subjects)
- Measuring behaviors while minimizing effects on behaviors
- Duration of study
- Biomarkers utilized
- Data interpretation--distribution-based, not means-based
- Knowledge of cigarettes, cigarette design, and smoking
- Utility of specialized smoker sub-group ("chippers")

Gaps in Understanding Compensation

- Mechanism of compensation
- Motivation for compensation
- Duration and degree of compensation

Key Question

How does compensation affect the harm reduction achieved by a reduced harm product?

Reduced Harm Products and Compensation

- Mechanism of partial compensation may depend on design of reduced harm product
- Extent of harm reduction may be affected by changes in smoking behavior
- Human exposure studies should provide requisite data

New publication

- Salivary cotinine measurements; derived nicotine intake values
- “Our results confirm that machine-smoked nicotine yields of cigarettes are poor predictors of nicotine intake in smokers.”

Jarvis, Martin; Boreham, Richard; et al., *JNCI*, 93(2), 134 - 138, 2001